Characteristics, classification and ordination of riparian plant communities in the Three-Gorges areas

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Abstract: Sixteen different vegetation types of grassland and shrubland were selected to study the component and diversity of plant species of riparian plant communities along main channel in the Three-Gorges areas. Species richness (*s*), Simpson index (*D*), and Shannon-Weiner index (*H*) were used to study the biodiversity and the hierarchical classification was carried out by the methods of TWINSPAN and DCA ordination. The results showed that the components of flora were complex and dominated by the temperate type in the riparian plant communities. Species diversity was not different between the communities, but Shannon-Weiner indexes of different layers in some grassland were significantly different. TWINSPAN and DCA indicated that riparian plant communities distributed along the gradient of moisture.

Keywords: Three-Gorges areas; Riparian zone; Plant community; Classification; Ordination; TWINSPAN; DCA
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Introduction

Riparian zone is the ecotone between aquatic ecosystem and terrestrial ecosystem, and in this zone, there exist obvious gradients of environmental factors, ecological process, and plant communities (Gregory *et al.* 1991). Riparian zone is the key ecosystem for controlling the adjacent aquatic ecosystem and terrestrial ecosystem. Riparian plant community, as an important component of riparian natural landscape, has high productivity and biomass. Being as the suitable habitat for some animals, riparian zone offers the corridor for removal of some animals and plants, and has an important function in buffering soil erosion and non-point resource pollution (Naiman *et al.* 1993; Deng *et al.* 2001). Therefore, more and more ecologists pay their attentions to riparian zone and are aware of the important effects of riparian zone in basic study and practical management (Deng *et al.* 2001). In the Three Gorges areas, there are 3 064 plant species and abundant biodiversities (Jin *et al.* 1984, 1987; Chen *et al.* 1994). Many studies on upper plant communities, plant flora, and biodiversity protection had been carried out (Jin *et al.* 1984, 1987; Chen *et al.* 1994), but no systemic study on riparian plant community. In this study, the components of flora and plant species diversity of riparian plant communities along main channel of Yangtze River in the Three Gorges areas were of Yangtze River in the Three Gorges areas were investigated, and the characteristics of the natural riparian plant communities were analyzed.

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Study sites and methods

Study area

The Three Gorges areas is located in central China, where is the transition zone between middle subtropics and north subtropics, and it belongs to the humid subtropical weather. The mean annual temperature is 16.5-19.0°C, and average temperature is 3.4-7.2°C in January and 28-30°C in July. The frost-free season is 300-340d. Annual precipitation averages about 1 100 mm. The precipitation from April to October is accounted for 80% of the total annual precipitation, but in July and August, drought often occurs. Calcareous rock is widely distributed in these areas, and the main soil types are yellow soil, red soil, yellow and palm soil, palm calcareous soil, paddy soil, and alluvial soil (Chen *et al.* 1993). Natural riparian vegetations along main channel of Yangtze River mostly are shrubland and grassland.

Methods

Sixteen different vegetation types of grassland and shrubland in the riparian zone were selected. For shrubland, the size of quadrat was 10 m×10 m, and for grassland, the size was 2 m×2 m. Basic status such as altitude, slope direction and degree, and total coverage of each quadrat were recorded at first. And other important data such as species component, abundance, coverage, and average height were investigated.

Species richness (S), Simpson index (D), and Shannon-Weiner index (H) were adopted to study the biodi-

versity.

$$D = \frac{N(N-1)}{\sum_{i=1}^{S} n_i(n_i-1)} \quad (1)$$

$$H = -\sum_{i=1}^{s} p_i \ln p_i \quad (2)$$

Here P_i and n_i are coverage and total individual number of species i, and N was the total individual of all species.

TWINSPAN method was used to classified riparian communities, and DCA method was used to do the ordination. As the calculating methods of TWINSPAN and DCA were similar, we also compared the results of TWINSPAN and DCA.

Results

Species component of plant communities in the riparian zone

According to the investigation data, there were 70 vascular plant species belonging to 67 genera and 37 families in the sampling quadrats along main channel of Yangtze River in Three Gorges areas. Among them, 3 pteridophyte species belong to 3 genera and 3 families. Based on the types of distribution areas (Wu 1991), we analyzed 64 genera of spermatophyte in the sampling quadrats and compared with 909 genera of spermatophyte in the Three Gorges areas (Table 1). The results showed that, of the 15 distribution-area types, 11 types were found in the riparian zone, and genera of riparian plants were multiple and complex in the riparian zone. The percentage of cosmopolitan (15.6%) in the riparian zone was higher than that in the Three Gorges areas, and it reflected the relationship between riparian zone and Three Gorges areas. Among the genera of riparian plants, the genera of tropic distribution plants (Pantropic, Trop. Asia & Trop. Amer. Disjuncted, Old World tropics, Tropical Asia & Trop. Australia, Trop. Asia to Trop. Africa, and Trop. Asia) and temperate distribution (North Temperate, East Asia & North Amer. Disjuncted, Old World Temperate, Temperate Asia, Mediterranean & West Asia to Central Asia, Central Asia, and East Asia) plants were accounted for 37.5% and 46.9% of the total 64 genera, respectively, and genera of temperate distribution was dominant. In brief, there existed obvious comparability between flora of riparian zone and flora of the Three Gorges areas, and the flora in riparian zone was more regional.

Table 1. Comparison of flora between riparian zone along main channel and the Three Gorges areas

Distribution area types	Number of genera in riparian zone	Number of genera in the Three Gorges Area
Cosmopolitan	10 (15.6%)	69 (7.6%)
Pantropic	13 (20.3%)	131 (14.4%)
Trop. Asia & Trop. Amer. disjuncted	0	12 (1.3%)
Old World tropics	3 (4.7%)	42 (4.6%)
Tropical Asia & Trop. Australia	1 (1.6%)	29 (3.2%)
Trop. Asia to Trop. Africa	6 (9.4%)	29 (3.2%)
Trop. Asia	1 (1.6%)	76 (8.4%)
North Temperate	15 (23.4%)	185 (20.4%)
East Asia & North Amer. Disjuncted	2 (3.1%)	71 (7.8%)
Old World Temperate	6 (9.4%)	56 (6.2%)
Temperate Asia	1 (1.6%)	18 (2.0%)
Mediterranean, West Asia to Central Asia	0	3 (0.3%)
Central Asia	0	1 (0.1%)
East Asia	6 (9.4%)	132 (14.5%)
Endemic to China	0	55 (6.0%)
Total	64 (100%)	909 (100%)

Biodiversity of riparian shrubland

Table 2 showed the species diversity indexes of the main shrubland in riparian zone in the Three Gorges areas. Species richness was different between the communities. In *Buxus harlandii* shrubland located on calcareous rock, there were only two species. In *Distylum chinense* shrubland, *Salix variegata* shrubland, and *Myricaria latiflora* shrubland, there were 4-6 species, and in other shrublands, there were more than 10 species. Except *Coriaria nepalensis* shrubland, the difference in species richness of shrub layer and herb layer were not significant between the sampling shrubland. According to Simpson index, there was no significant difference between different layers in the sampling shrubland except *Myricaria latiflora* shrubland, and according to Shannon-Weiner index, there was no significant difference between different layers in the sampling shrubland except *Coriaria nepalensis* shrubland.

Table 2. Species diversity indexes of the main shrubland in riparian zone in the Three Gorges area

Community types	Layer	Richness	Simpson index	Shannon index
Coriaria nepalensis shrubland	Shrub	15	0.30	1.65
	Herb	5	0.61	0.80
Distylum chinense shrubland	Shrub	2	0.95	0.12
	Herb	4	0.71	0.62
Buxus harlandii shrubland	Shrub	1	1.00	0
	Herb	1	1.00	0
Salix variegata shrubland	Shrub	1.5	0.67	0.35
	Herb	3	0.69	0.66
Myricaria latiflora shrubland	Shrub	2.5	0.70	0.48
	Herb	1.5	0.19	0.52
Indigofera pseudotinctoria shrubland	Shrub	6	0.34	1.41
	Herb	6	0.23	1.58

Biodiversity of riparian grassland

Table 3 showed the species diversity indexes of the main grassland in riparian zone in the Three Gorges areas. Species richness had no difference between the communities except *Cynodon dactylon* grassland, which included only 3 species. According to Simpson indexes, there was no significant difference between all the communities, and also no difference for Shannon-Weiner indexes of different layers in *Arundinella hirta* grassland and *Cynodon dactylon* grassland. In other grassland, Shannon-Weiner indexes of different layers were significantly different. Compared Table 2 with Table 3, the result showed that the biodiversity was not significantly different between shrubland and grassland.

Table 3. Species diversity index of the main grassland in riparian zone in the Three Gorges areas

Community types	Layer	Richness	Simpson index	Shannon index
Pogonatherum crnitum grassland	Shrub	4	0.44	1.07
	Herb	4	0.82	0.41
Miscanthus floridulus grassland	Shrub	2	0.50	0.69
	Herb	9	0.35	1.39
Arundinella hirta grassland	Shrub	4	0.25	1.39
	Herb	6	0.32	1.32
Heteropogon contortus grassland	Shrub	2	0.72	0.45
	Herb	4	0.80	1.01
Saccharum arundinaceum grassland	Shrub	4	0.76	0.53
	Herb	11	0.51	1.04
Imperata cylinderica var. major grassland	Shrub	12	0.16	2.12
	Herb	5	0.64	0.74
Cynodon dactylon grassland	Herb	3	0.38	1.03

Classification and ordination of riparian plant communities

The riparian plant communities along main channel of Yangtze River in The Three Gorges areas were classified by the TWINSPAN method, and the results showed that 16 riparian plant communities could be divided into 6 groups finally (in Fig. 1). One of the groups (G8) included sampling quadrat 1 (*Coriaria nepalensis* shrubland) and 2 (*Distylum chinense* shrubland), and the two types of shrublands were mainly located in the transition belt from bottomland to upland. G9 included quadrat 5 (*Miscanthus floridulus* grassland), 7 (*Saccharum arundinaceum* grassland), 15 (*Indigofera pseudotinctoria* shrubland), and 16 (*Imperata cylinderica* var *major* grassland), which were mainly located in the bottomland. G5 included quadrat 4 (*Pogonatherum crnitum* grassland), 6 (*Arundinella hirta* grassland), and 8 (*Heteropogon contortus* grassland), and it's habitat was similar to that of G9. G12 included quadrat 9 (*Salix variegata* shrubland), 10 (*Salix variegata* and *Myricaria latiflora* shrubland), 11 (*Myricaria latiflora* shrubland), 12 (*Salix variegata* shrubland), and 13 (*Myricaria latiflora* shrubland), and these shrublands were mainly located in the riverbank. G13 included quadrat 14 (*Cynodon dactylon* grassland) only, and this grassland was located near the bottomland. G7 included quadrat 3 (*Buxus harlandii* shrubland), which was located on calcareous rock only. The results of TWINSPAN reflected the moisture condition of different plant communities in the riparian zone perfectly.

Fig. 2 showed the DCA ordination results of riparian plant communities. In Fig.2 the first axes (horizontal axes) represent moisture, and the 16 riparian plant communities were differentiated commendably. The consistency between results of TWINSPAN and DCA confirmed the com-

parability of TWINSPAN and DCA method.

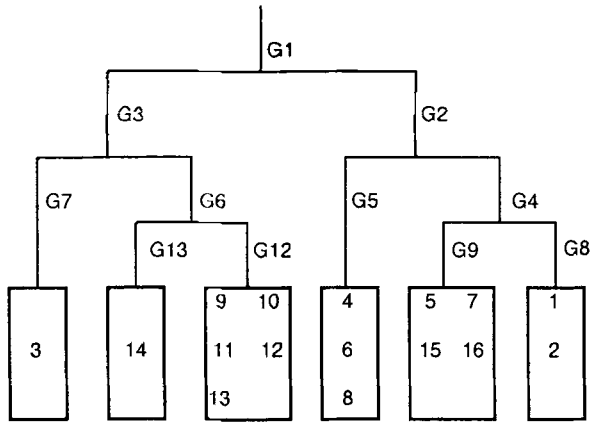

Fig. 1 TWINSPAN classification of riparian plant communities
1. *Coriaria nepalensis* shrubland, 2. *Distylum chinense* shrubland, 3. *Buxus harlandii* shrubland, 4. *Pogonatherum crnitum* grassland, 5. *Miscanthus floridulus* grassland, 6. *Arundinella hirta* grassland, 7. *Saccharum arundinaceum* grassland, 8. *Heteropogon contortus* grassland, 9. *Salix variegata* shrubland, 10. *Salix variegata* and *Myricaria latiflora* shrubland, 11. *Myricaria latiflora* shrubland, 12. *Salix variegata* shrubland, 13. *Myricaria latiflora* shrubland, 14. *Cynodon dactylon* grassland, 15. *Indigofera pseudotinctoria* shrubland, 16. *Imperata cylinderica* var *major* grassland

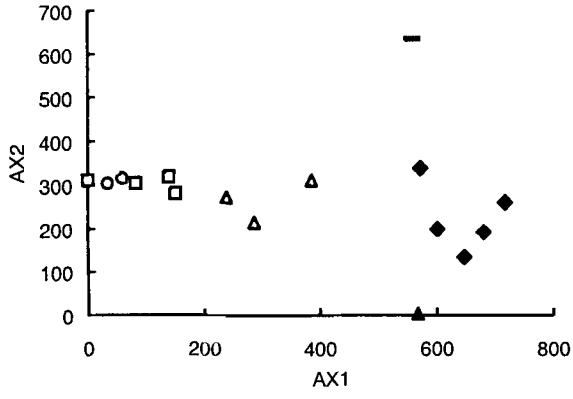

Fig. 2 DCA ordination of riparian plant communities

Conclusion

There were 70 vascular plant species belonging to 67 genera and 37 families in the sampling quadrats along main channel of Yangtze River in Three Gorges areas. Among them, there were 3 pteridophyte species belonging to 3 genera and 3 families. Analysis of the component of plant flora showed that genera of riparian plant were multiple and complex. The percentage of cosmopolitan in the riparian zone was higher than that in the Three Gorges areas, and genera of temperate distribution was dominant. It showed that there existed obvious comparability between flora of riparian zone and the Three Gorges areas, and the flora in the riparian zone was more regional.

Species diversities were not significantly different between the shrubland and grassland communities in the riparian zone, but Shannon-Weiner indexes of different layers in some grassland were significantly different. TWINSPAN and DCA indicated that riparian plant communities distributed mainly along the gradient of moisture. The riparian plant communities along main channel of Yangtze River in The Three Gorges areas were classified into 6 groups by TWINSPAN, and the results of TWINSPAN reflected the moisture condition of different plant communities in the riparian zone perfectly. The horizontal axes of DCA ordination reflected moisture, and the 16 riparian plant communities were differentiated commendably. The consistency between results of TWINSPAN and DCA confirmed the comparability of TWINSPAN and DCA.

References

Chen Guojie. 1993. Studies on influences of Three Gorges Project on ecological environment [M]. Beijing: Science Press.

Chen Weilie, Zhang Xiqun, Liang Songjun, *et al.* 1994. Plants and complex agriculture ecosystems in the reservoir region of Three Gorges [M]. Beijing: Science Press.

Deng Hongbing, Wang Qingchun, Wang Qingliu, *et al.* 2001. On Riparian Forest Buffers and Riparian Management [J]. Chinese Journal of Applied Ecology, **12**(6): 951-954.

Gregory, S.V., Swanson, F.J., McKee, W.A., *et al.* 1991. An ecosystem perspective of riparian zones [J]. BioScience, **41**(1): 540-550.

Jin Yixing, Chen Zhuoliang, Zheng Zhong, *et al.* 1984. A report on the expedition of vegetation and environment in Changjiang Sanxia (Gorge of Yangtze River) Reservoir Region [J]. Wuhan Botanical Research, **2**(Supp.): 1-100.

Jin Yixing, Chen Zhuoliang, Zheng Zhong, *et al.* 1987. Influence of Three Gorges Project on the rare plants in the reservoir region and its countermeasure [M]. In: Collected works on ecological and environmental influence of Three Gorges Project and its countermeasure. Beijing: Science Press. p114-122.

Naiman, R.J., Decamps, H. and Pollock, M. 1993. The role of riparian corridors in maintaining regional biodiversity [J]. Ecological Applications, **3**(2): 209-212.

Wu Zhengyi. 1991. Distribution area types of spermatophyte genera in China [J]. Yunnan Botanical Research, IV(Supp.): 1-139.